413-173.1

'77-09

SEP 1977

PATENT SPECIFICATION (11) 1 484 288

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(21) Application No. 52998/74 (22) Filed 7 Dec. 1974

(23) Complete Specification filed 3 Dec. 1975

(44) Complete Specification published 1 Sept. 1977

(51) INT. CL.[2] F01D 11/08

(52) Index at acceptance

F1T 3A2 3B B2E

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(19)

(54) IMPROVEMENTS IN OR RELATING TO GAS TURBINE ENGINES

(71) We, ROLLS-ROYCE LIMITED formerly ROLLS-ROYCE (1971) LIMITED, a British Company of 65 Buckingham Gate, London SW1, formerly of Norfolk House, St. James's Square, London, SW1Y 4JR, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to gas turbine engines and more particularly to a sealing assembly for sealing the blade tips of an "unshrouded" type of gas turbine engine turbine rotor.

The difficulties of tip sealing this type of blade have been well known for many years. This problem has become worse as the size of gas turbine engines is reduced and the working temperature is increased. One of the main factors which has to be considered when attempting to design a satisfactory sealing arrangement is the matching of respective diameters of the stator and the rotor at working temperature taking into account the differing coefficients of expansion of the materials used in the turbine rotor and stator construction.

It may also be appreciated that whilst striving to obtain the above working conditions the design must be such that any interference due to expansion must be avoided at transient conditions. The design must also be such that any eccentricity of the rotor and turbine due to tolerance and bearing clearances etc. must also be kept to a minimum, and it is also necessary to keep the amount of ovality or distortion of the respective components to a minimum.

Accordingly the present invention provides a gas turbine engine including a seal comprising a sealing ring spaced from engine structure to form a sealing clearance therebetween, a first annular sensing member to which the sealing ring is connected for movement therewith, a second annular sensing member having restraining means co-operating with the first sensing member for restraining relative movement between the two members, wherein the first annular sensing member has a higher initial rate of thermal expansion or contraction than the second sensing member such that the first sensing member will expand relatively quickly in accordance with a temperature increase, but the restraining means will restrain the rate of contraction of the first sensing member to that of the second sensing member with a decrease in temperature.

Preferably a first working fluid supply means is provided for supplying fluid to the first annular sensing member to cause expansion or contraction thereof to vary the sealing clearance, and a second working fluid supply means is provided for supplying working fluid to both the first and the second annular sensing members and which is operable only after initial expansion of the first annular sensing member.

The annular sealing ring may comprise a plurality of segmental portions arranged to slide circumferentially with respect of each other, alternatively the annular sealing ring may comprise a continuous ring of deformable material.

The first and second annular sensing members and the annular sealing ring may be arranged coaxially with respect of each other.

In one embodiment the first annular sensing member is connected to the annular sealing ring by means of a circumferentially extending array of dowels which co-operate with flanges provided adjacent one end of both of the members, and by means of an axially extending spigot extending into an annular channel provided upon the face of a flange provided upon the annular sealing ring.

Preferably the first fluid supply means

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comprises a circumferentially extending array of holes provided within a flange of the annular sealing ring.

After initial expansion of the first annular sensing member an annular aperture constituting the second working fluid supply means may be formed between the first and second annular sensing members such as to allow a flow of working fluid to pass between the first and second annular sensing members such as to increase the rate of expansion of both the first and second annular sensing members.

The first annular sensing member may be provided with a plurality of axially extending fins on both its internal and external surfaces to improve the heat transfer properties of the member.

Preferably the restraining means co-operating with the first and second annular sensing members comprises a radially extending projection provided upon the second annular sensing member terminating in an axially extending projection which co-operates with an internal shoulder at the first end of the first annular sensing member, and an axially extending projection which co-operates with an axial shoulder provided upon the second end of the first annular sensing member.

The working fluid after serving to heat up the first annular sensing member may be directed such as to impinge upon the sealing ring to cool the ring.

Preferably the supply of working fluid comprises a supply of high pressure air tapped from the high pressure compressor of the engine.

A layer of abradale material may be attached to the surfaces of the sealing ring.

An embodiment of the invention will now be more particularly described by way of example only and with reference to the accompanying drawings in which: —

Figure 1 shows a pictorial side elevation of a gas turbine engine having a broken away casing portion showing a diagrammatic embodiment of the present invention applied to the turbine of an engine.

Figure 2 shows an enlarged cross-sectional view in greater detail of the seal arrangement applied to a turbine shown at Figure 1.

Referring to Figure 1, a gas turbine engine shown generally at 10 comprises an intake 12, a low pressure compressor 13, high pressure compressor 14, combustion equipment 15, high pressure turbine 16, low pressure turbine 17 terminating in exhaust nozzle 18. The low pressure compressor 13 and low pressure turbine 17, and high pressure compressor 14 and high pressure turbine 16 are rotatably mounted upon two coaxially arranged engine main shafts not shown. A diagrammatic view of those parts incorporating the present invention is shown at 11 through a broken away portion of the turbine casing.

Figure 2 shows an enlarged cross-sectional view of the sealing arrangement shown diagrammatically at 11 at Figure 1 which comprises a first annular member 19 constituting the first annular sensing member which is supported by means of a thin flexible conical member 20 attached to fixed structure not shown. A plurality of longitudinally extending relatively thin section radially projecting fins 20*a* are arranged on both the external and the internal surfaces of the annular sensing member 19. The fins serve to increase the surface area at the annular member 19 such as to improve its heat transfer properties, and also to prevent distortion of the relatively thin section member.

Secured radially inwards of the first annular sensing member 19 is an annular sealing ring 21 which comprises a plurality of segments which are adapted to slide relative to each other and which are each secured to the first annular sensing member. The securing means comprise a circumferentially extending array of axially disposed dowels 22 which co-operate with adjacent flanges 23 and 24 provided upon the first annular sensing member 19 and the sealing ring 21 respectively and which serve to secure the downstream ends of the two members. To secure the upstream end the securing means comprises an axially extending flange 25 provided upon the first annular sensing member 19 which co-operates with an annular channel provided within the rearmost surface of a radially extending flange 26 forming a portion of the annular sealing ring 21.

A second annular sensing member 27 is provided radially outwards of the first annular sensing member which is also supported by a thin flexible conical member, the annular sensing member 27 being of a substantially greater mass than the first annular sensing member 19, the member 27 serving to stiffen the assembly and helps to prevent distortion. It should be understood that whilst both the sensing members 27 and 19 have been described as being supported by thin flexible conical members, they could equally well be supported by any suitable alternative flexible support structure, the deciding factor being that they must be supported such as to expand or contract independently of the engine casing. The second annular sensing member 27 is provided with means which co-operate with the first annular sensing member 19. The means comprise two axially extending spigots portions 28 and 29 one being arranged at either end of the second annular sensing member 27 which co-operate with two further axially extending projections 30 and 31 provided upon the first annular sensing member 19

in the present device.

Upon starting up the engine a supply of high pressure delivery air is bled from the high pressure compressor shown generally at 14 and is directed by means of a plurality of axially extending holes 32 into an annular space 33 defined between the internal surface of the first annular sensing member 19 and a portion of the annular sealing ring 21. The high pressure air upon entering space 33 serves to heat up the first annular sensing member 19 such that it quickly expands in accordance with the temperature of the high pressure air. The expansion of the member 19 thus also expands the plurality of segments constituting the annular sealing ring 21 by virtue of the fact that the two are secured to each other by means of dowels 22, and axially extending spigot 25. The expansion of the sealing ring 21 therefore maintains an adequate clearance between the ring 21 and the tips of the turbine blades 12*a* upon thermal growth of the turbine.

The high pressure air after entering the annular space 33 is directed through a plurality of holes 34 arranged within an axially extending wall arranged within the sealing ring 21. The high pressure air upon exiting from the plurality of holes 34 impinges upon the innermost internal surface of the annular sealing ring such as to provide a degree of cooling to it. The air is subsequently exhausted through two circumferentially extending arrays of axial holes 35 and 36 into the hot gas stream of the turbine.

By virtue of the differing rates of expansion of the annular sensing members 19 and 27 upon the initial expansion of the first annular sensing member 19 an annular space is formed between the axially extending portions 31 and 28 provided upon the first annular sensing member 19 and the second annular sensing member 27. The annular space thus provides for an additional supply of high pressure air which serves to speed up the rate of expansion of the first annular sensing member 19, and also serves to heat up the second annular sensing member 27. It will be appreciated that the second annular sensing member 27 will expand relatively slowly in comparison with the first annular sensing member 19 because of its differing mass.

When the engine reaches a normal running condition the annular sensing members 19 and 27 will remain in substantially the locations illustrated in Figure 2 of the drawings. When the speed of the engine is either reduced to an idling condition or alternatively shut down completely the first annular sensing member 19 will attempt to contract relatively quickly in accordance with the relatively small mass thus reducing the diameter of the sealing ring 21 and therefore shutting of the additional supply of high pressure air which passes through the annular space provided between axially extending portions 31 and 28. However the first annular sensing member 19 is restrained from contracting relatively quickly by virtue of the axially extending projections 28 and 29 provided upon the second annular sensing member 27 which co-operate with portions 30 and 31 provided upon the first annular sealing member 19. Therefore the diameter of the sealing ring 21 is controlled by the rate of contraction of the second annular sensing member 27. In this way an adequate clearance is maintained between the turbine blades 12*a* and the sealing ring 21 on engine run-down.

As will be seen from the embodiment illustrated in Figure 2 of the drawing it has been found desirable to provide a layer of abradable or porous material 37 to the innermost surface of the sealing ring 21 to protect the sealing ring should any turbine blade rub occur through turbine misalignment etc.

WHAT WE CLAIM IS:—

1. A gas turbine engine including a seal comprising a sealing ring spaced from engine structure to form a sealing clearance therebetween, a first annular sensing member to which the sealing ring is connected for movement therewith, a second annular sensing member having restraining means co-operating with the first sensing member for restraining relative movement between the two members, wherein the first annular sensing member has a higher initial rate of thermal expansion or contraction than the second sensing member such that the first sensing member will expand relatively quickly in accordance with a temperature increase, but the restraining means will restrain the rate of contraction of the first sensing member to that of the second sensing member with a decrease in temperature.

2. A gas turbine engine including a seal as claimed in claim 1 in which a first working fluid supply means is provided for supplying fluid to the first annular sensing member to cause expansion or contraction thereof to vary the sealing clearance, and a second working fluid supply means is provided for supplying working fluid to both the first and the second annular sensing member and which is operable only after initial expansion of the first annular sensing member.

3. A gas turbine engine including a seal as claimed in claim 1 in which the annular sealing ring comprises a plurality of segments arranged to slide circumferentially with respect to each other.

4. A gas turbine engine including a seal as claimed in claim 1 in which the annular sealing ring comprises a continuous ring of deformable material.

5. A gas turbine engine including a seal device as claimed in claim 1 in which the first and second annular sensing members and the annular sealing ring are arranged coaxially with respect of each other.

6. A gas turbine engine including a seal device as claimed in claims 1 and 5 in which the first annular sensing member is connected to the annular sealing ring by means of a circumferentially extending array of dowels which co-operate with flanges provided adjacent one end of both of the members, and by means of an axially extending spigot extending into an annular channel provided upon the face of a flange provided upon the annular sealing ring.

7. A gas turbine engine including a seal device as claimed in claim 2 in which the first fluid supply means comprises a circumferentially extending array of holes provided within a flange of the annular sealing ring.

8. A gas turbine engine including a seal device as claimed in claim 2 in which after initial expansion of the first annular sensing member an annular aperture constituting the second working fluid supply means is formed between the first and second annular sensing members such as to allow a flow of working fluid to pass between the first and second annular sensing members such as to increase the rate of expansion of both the first and second annular sensing members.

9. A gas turbine engine including a seal device as claimed in claims 1, 3, 5 and 8 in which the first annular sensing member is provided with a plurality of axially extending fins on both its internal and external surfaces to improve the heat transfer properties of the member.

10. A gas turbine engine including a seal device as claimed in claim 1 in which the restraining means co-operating with the first and second annular sensing members comprises a radially extending projection provided upon the second annular sensing member terminating in an axially extending projection which co-operates with an internal shoulder at the first end of the first annular sensing member, and an axially extending projection which co-operates with an axial shoulder provided upon the second end of the first annular sensing member.

11. A gas turbine engine including a seal as claimed in claims 2, 7 and 8 in which the working fluid after serving to heat up the first annular sensing member may be directed such as to impinge upon the sealing ring to cool the ring.

12. A gas turbine engine including a seal as claimed in claims 2, 7, 8 and 11 in which the supply of working fluid comprises a supply of high pressure air tapped from the high pressure compressor of the engine.

13. A gas turbine engine including a seal as claimed in claim 1 in which a layer of abradale material is attached to the radially inner surface of the sealing ring.

14. A gas turbine engine including a seal as claimed in any preceding claim substantially as hereinbefore described with reference to the accompanying drawings.

For the Applicant.
J. WAITE,
Chartered Patent Agent.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1977. Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1 484 288 COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

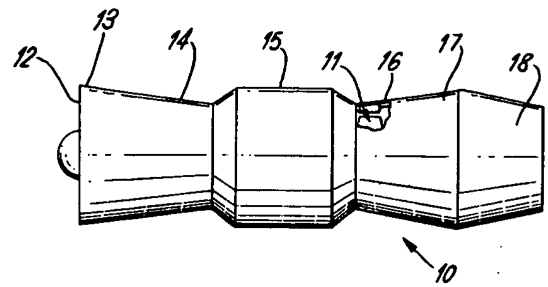

FIG. 1.

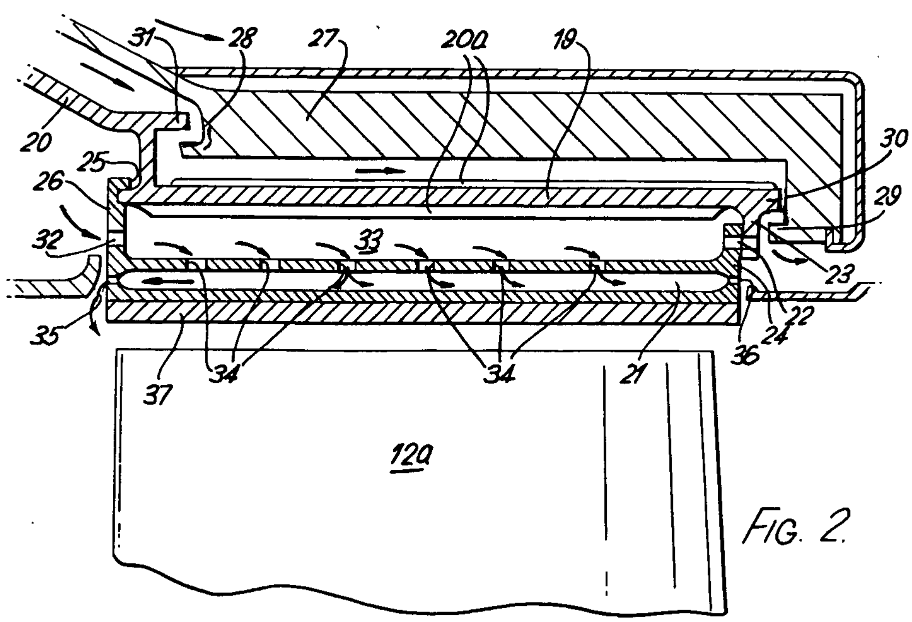

FIG. 2.